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ABSTRACT

The paper describes the use of an operant procedure to assess the speech perception of 11 young (7 to 35 months old) hearing impaired children and 11 normally hearing subjects. Subjects were presented with a repeating background stimulus and conditioned to turn their head on presentation of a contrasting syllable. The head-turning responses were reinforced with the activation of visual reinforcers (three lighted, moving mechanical toys). Stimuli were presented at either 25 or 100 dB depending on subject hearing status. Among findings were the following: both physiologic impairment and abundance of acoustic cuing affected speech sound discrimination; speech discrimination ability in hearing impaired infants may decline with age; and vowels were more easily differentiated than semivowels or consonants. The assessment method allows for clinical assessment of speech perception ability in infants for whom present, language-based, pediatric audiometric procedures are inappropriate. Attached material details the study methodology and findings. Includes 13 references. (DB)

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# Assessment of Auditory Speech Perception in Hearing-Impaired Infants

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Paper presented at the meeting of the
International Congress on Education of the Deaf
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July 30, 1990

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**Assessment of Auditory Speech Perception in Hearing-Impaired Infants**

At the present time, assessing children's speech perception abilities in clinical or educational settings requires repetition or picture pointing responses. It also demands a receptive language age of at least four years. However, this lexical competence is typically not achieved by severely hearing-impaired children until seven or eight years of age. As a result, young hearing-impaired children's perception of the complex, rapidly changing sounds of speech has remained largely unexplored.

This situation is of special concern, since early intervention offers significant advantages for auditory learning in young hearing-impaired listeners, but our ability to test these abilities is largely restricted to assessing threshold or sound awareness. We have no means of assessing early speech perception abilities.

In the present study, an operant procedure, similar to Visual Reinforcement Audiometry, was used to assess speech perception in young hearing-impaired listeners. Results are intended to provide: 1) information about the effects of hearing impairment on speech perception in early life, 2) a better understanding of the factors that influence early speech perception, and 3) a foundation for developing clinical speech perception tasks for use with young hearing-impaired listeners.

The technique used was adapted from one used to study speech perception in normally-hearing infants, most extensively by Rebecca Eilers and her colleagues. With this method, a repeating background stimulus is presented, and a head-turning response is conditioned to the presentation of a contrasting syllable. These head-turning responses are reinforced with the activation of an attractive visual display that I'll describe in a moment.

In the present study, eleven 7 to 35 month-old hearing-impaired children and 11 normally-hearing subjects, 8- to 36-months-old, were evaluated. Mean chronological ages were 24.0 months for normally-hearing subjects and 25.9 months for hearing-impaired subjects.

This slide presents developmental age-equivalent scores for all children. These were obtained using the Vineland Adaptive Behavior Scale. As you can see, signficant differences between normally-hearing and hearing-impaired groups were noted only in the communication domain of the Vineland, with means of 24.4 and 14.1 months, respectively.

The next slide shows the audiometric data for all children. The pure tone average at 500, 1000, and 2000, was calculated for each ear. The better ear pure tone average was 18.8 dB HL for normally-hearing subjects and 91.4 dB for hearing-impaired subjects.

This slide shows the test environment. Each child sat on his or he parent's lap, or in a chair in front of the parent. An experimenter was seated in a chair directly to the child's left.

The control room contained a two channel audiometer with auxiliary amplifier and a two channel reel-to-reel tape deck. Both experimenters had response-vote buttons, and the experimenter in the test suite had a foot-operated switch. This switch was used to signal the second experimenter to begin an experimental trial.

The visual reinforcers were three lighted, moving mechanical toys. Each was separately lighted and encased in smoked plexiglas of the type often used in clinical practice. These reinforcers were connected to an and-gate and timer. With the timer, each experimenter had six seconds in which to vote that a child had given a response. One of the reinforcers was activated only if both experiementers signaled within that six-second period.

Discrimination of three synthetically produced stimulus pairs was assessed. These pairs are perceived by adult English speakers as /ua-ia/, /wa-ya/, and /ba-ga/, reflecting a bilabial-velar contrast in place of articulation for the initial segment in each pair. Spectral differences within pairs are shown in the line spectrograms here. The duration and trajectory of the initial formant transitions was the sole difference across stimulus pairs, with values of 150, 75, and 25 ms, perceived by adult listeners as vowels, semivowels, or plosives consonants, respectively. A steady state /a/ vowel followed the initial segment in all cases.

Stimuli were presented binaurally through earphones. Presentation level was 25 dB Sensation Level for subjects with hearing better than 75 dB. For subjects with more severe losses, stimuli were presented at 100 dB HL. The order of presentation of the three stimulus pairs was randomized across subjects.

For each stimulus pair, trials were presented in three 10-trial blocks. The next slide illustrates the two types of trials which were used. The top of the slide shows a change trial: Here the contrasting member of the stimulus pair was presented. The bottom of the slide shows a control trial in which no change was introduced. Trials within each block were presented in a predetermined pseudorandom order.

Each child was conditioned to turn toward the reinforcers when a stimulus change was detected. Subjects had to reach an 8-out-of-10 criterion on a discrete block of 10 trials for a vowel training task before experimental stimuli were introduced.

Scores were recorded as the number of correct responses for the 30 trials for each stimulus pair. Correct responses were head-turns to stimulus change trials and no head-turn to control intervals.

Mixed Analysis of Variance with repeated measures was used to explore effects of hearing status and formant transition duration on children's discrimination scores.

This slide shows the performance of the two groups of subjects for each stimulus pair (/ba-ga/, /wa-ya/, and /ua-ia/). As expected, significant differences in discrimination ability between normally-hearing and hearing-impaired subjects were observed. Longer transitions were more readily discriminated by both groups than brief transitions. This corresponds to the common observation that vowels are discriminated more readily than semivowels, which are in turn discriminated more easily than consonants. No significant interaction of hearing status and transition duration was observed.

With respect to these results, I would now like to briefly discuss: 1) the observed effects of hearing status and transition duration on speech discrimination, 2) apparent effects of auditory-linguistic deprivation, and 3) the clinical implications of the present study.

Effects of hearing loss and stimulus type. Other researchers have reported that three factors appear to affect the development of speech discrimination. The physiologic status of the auditory system, the acoustic salience of the stimulus to be perceived, and the young listener's prior auditory-linguistic experience.

Present data are consistent with this hypothesis. Both physiologic impairment--in the form of sensorineural hearing loss--and abundance of acoustic cuing were shown to affect speech sound discrimination.

Hearing-impaired infants showed significantly poorer discrimination for all stimulus pairs than their normally-hearing peers. Moreover, both hearing-impaired and normally-hearing subjects showed superior discrimination for stimulus contrasts marked by long formant transitions than by short transitions.

Experience. For the second point, early listening experience appears to affect normally-hearing infants' speech perception in one of three ways. First, infants appear to discriminate contrasts for which robust acoustic cues are available without significant auditory experience. But auditory-linguistic experience appears to improve discrimination of subtly cued speech sound contrasts. They found that infants' discrimination may decline when experience with such contrasts is not available during the first year of life.

Data from the present experiment also suggest that speech discrimination ability in hearing-impaired infants may decline with age. Specifically, only the two youngest hearing-impaired subjects, who were less than 12 months of age, showed evidence of discrimination for the subtly cued 25 ms /ba-ga/ contrast. Moreover, a marked negative correlation was observed between age and discrimination ability. This association was not seen for the longer formant transitions cuing /wa-ya/ or /ua-ia/. Neither was it observed in normally-hearing subject

The notion that speech perception abilities are shaped by auditory-linguistic experience is of particular importance with hearing-impaired children, since, as a result of hearing loss, the crucial experiences may not be available. Not only may hearing-impaired children fail to experience developmental improvement for difficult speech sound contrasts, but they may cease responding to potentially useful cues.

Finally, the clinical implications of this study must be addressed. The visually reinforced procedure used to assess speech perception holds considerable potential for clinical application. It would allow clinical assessment of speech perception ability in infants for whom present, language-based, pediatric audiometric procedures are inappropriate.

For the future. However, a variety of issues remain to be addressed. The equivalence between discrimination measures such as those used here and performance on conventional audiometric tasks--and indeed, on the real world functioning--of hearing-impaired children remain to be explored. An educationally meaningful set of speech sound contrasts must be developed for use in assessment.

In addition, it may be possible to develop alternative response and reinforcement modes for use with older preschool and low-verbal hearing-impaired children.

Conclusion. In conclusion, then, present findings--that normally-hearing children hear speech better than hearing-impaired children, and that vowels are more easily differentiated than semivowels or consonants--are not remarkable.

What is remarkable is that it was possible to document such differences in a population of infants with hearing losses ranging from moderate to profound.

Educators and audiologists working with deaf infants have long been limited to measures of threshold techniques in assessing auditory function in young hearing-impaired children. Present findings, however, suggest that it is possible to assess the quality of auditory function in deaf infants as early as the seventh month of life, and in the absence of spoken language skills.

The results of the study described here are merely suggestive of the spectrum of theoretical, clinical, and educational issues which remain to be addressed in an infant population of speech-perceivers--be they normally-hearing or hearing-impaired.

Thank you!!!

Chronological Age and Developmental Age Equivalents (in months) for Hearing Impaired and Normally Hearing Subjects as Assessed with the Vineland Adaptive Behavior Scale (Sparrow et al., 1984)

| Age Equivalent | Subjects: Normally Hearing | Subjects: Hearing Impaired | Differences Between Means: t(20) | Differences Between Means: p |
|---|---|---|---|---|
| Chronological | | | | |
| Mean | 24.0 | 25.9 | 0.46 | .6477 |
| SD | 9.6 | 9.7 | | |
| Communication | | | | |
| Mean | 24.4 | 14.1 | -2.48 | .0264 |
| SD | 12.5 | 5.8 | | |
| Daily Living Skills | | | | |
| Mean | 21.7 | 25.3 | 0.85 | .4037 |
| SD | 8.4 | 10.9 | | |
| Socialization | | | | |
| Mean | 21.5 | 20.7 | -0.24 | .0841 |
| SD | 7.5 | 6.7 | | |
| Motor Skills | | | | |
| Mean | 25.9 | 28.1 | 0.40 | .6967 |
| SD | 13.8 | 12.1 | | |
| Developmental | | | | |
| Mean | 22.6 | 22.5 | -0.05 | .9628 |
| SD | 9.8 | 8.2 | | |



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Pure Tone Thresholds for the Better-Hearing Ear*

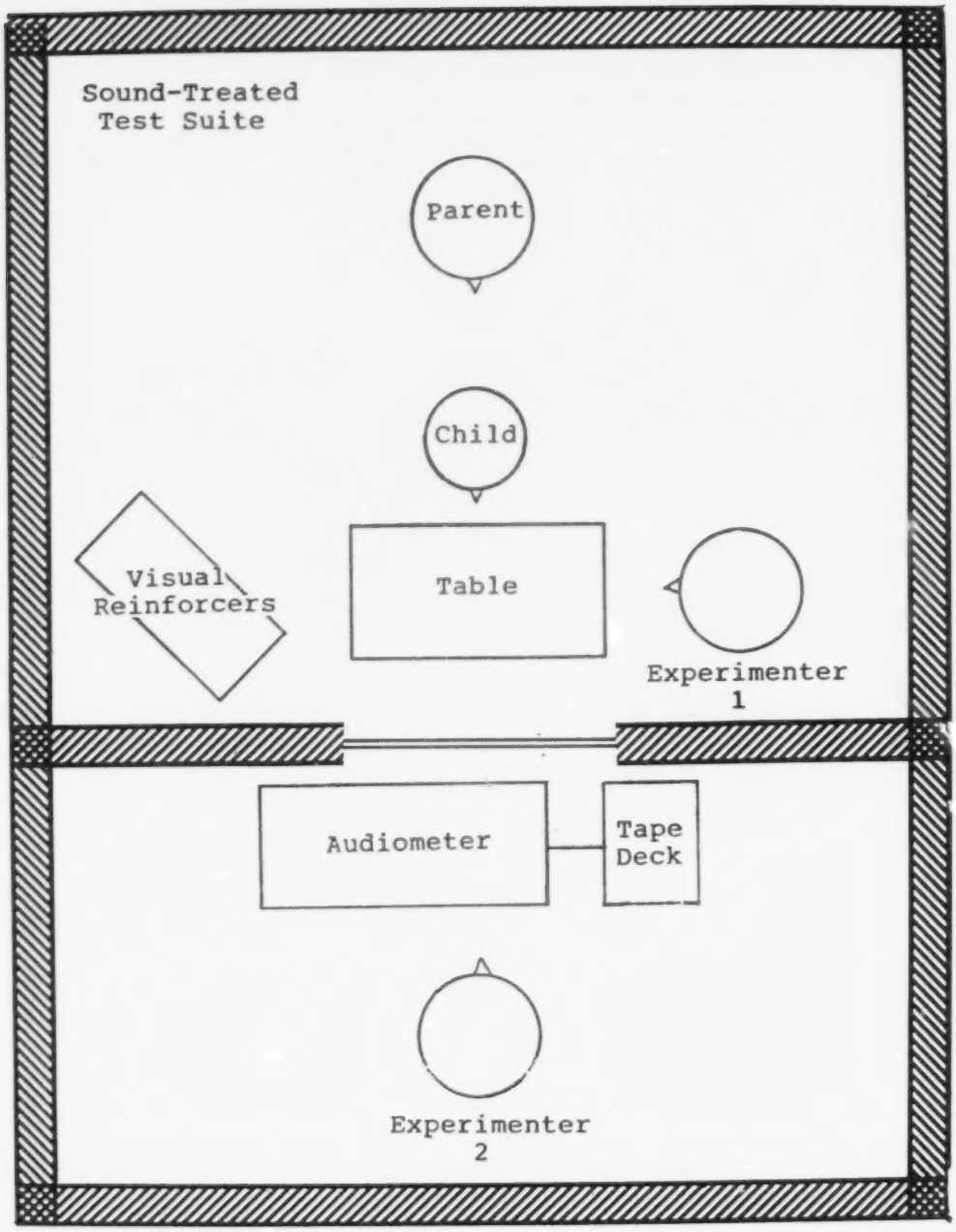
(in dB HL re ANSI 1969)

| | Frequency in Hz | | |
|---|---|---|---|
| Group | 500 | 1000 | 2000** |
| Hearing Impaired | | | |
| Mean | 85.0 | 92.3 | 96.8 |
| SD | 19.0 | 14.6 | 20.0 |
| Normally Hearing | | | |
| Mean | 20.9 | 18.6 | 17.7 |
| SD | 5.4 | 7.1 | 3.4 |

* The better ear was the right ear for 6 NH subjects and 7 HI subjects.

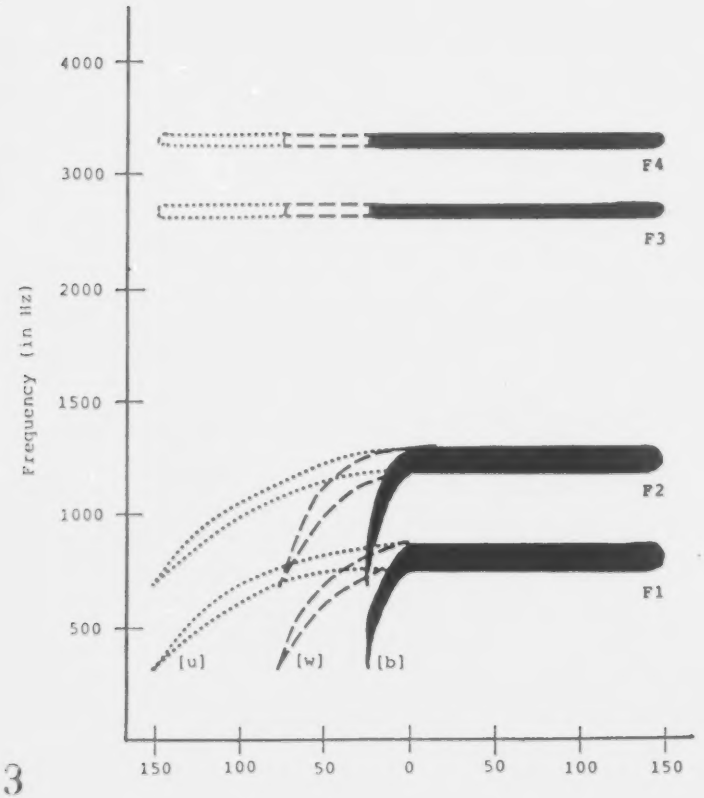
** Four HI subjects showed no response to 110 dB HL at 2000 Hz. For computation purposes, these were assigned values of 115 dB HL.

Slide 3


Sound-Treated
Test Suite
Parent
Child
Visual
Reinforcers
Table
Experimenter
1
Audiometer
Tape
Deck
Experimenter
2

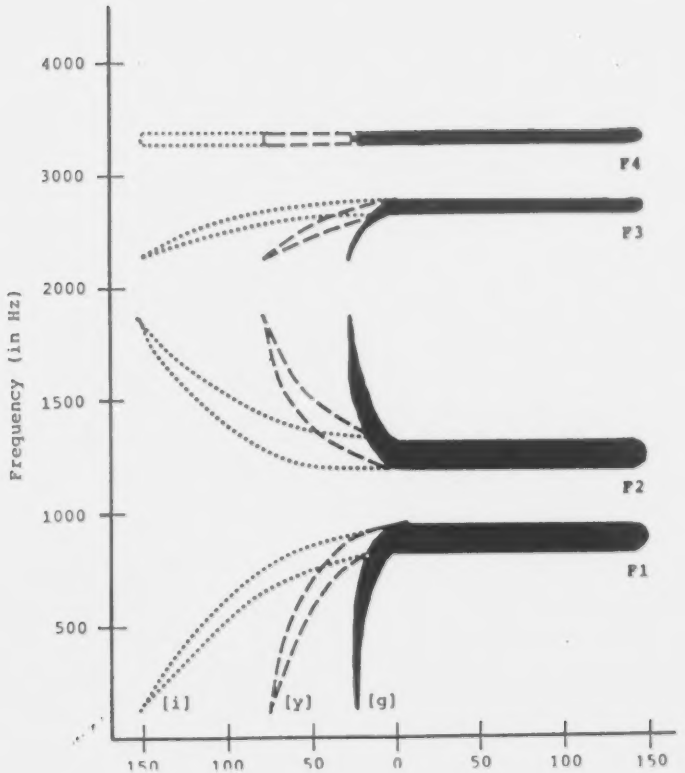
Formant Transition Frequencies: Initial and Terminal Steady State Values for Test Stimuli

| | Formant frequencies (in Hz) | | |
|---|---|---|---|
| | Initial | | Steady state |
| Formant | Labial | Velar | |
| F1 | 300 | 150 | 745 |
| F2 | 600 | 1900 | 1200 |

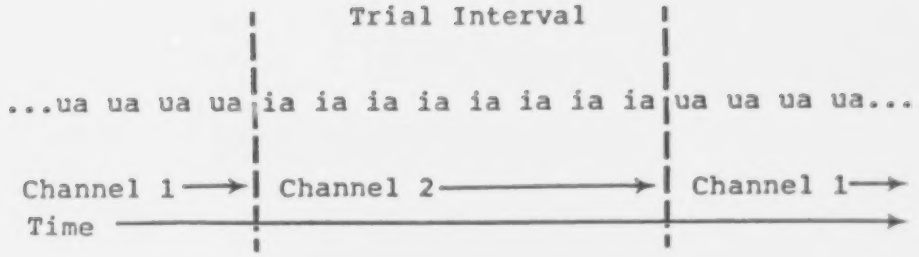




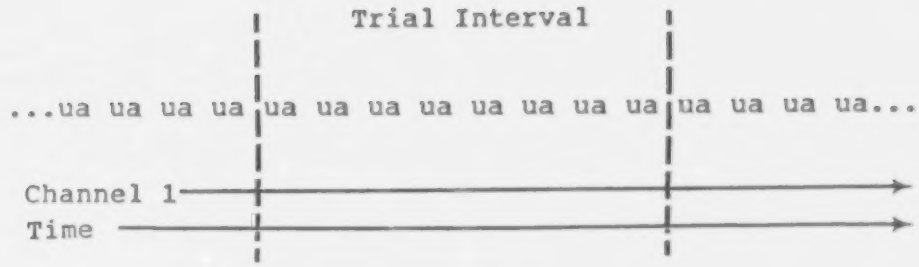

Slide 4
Facsimile



Slide 5



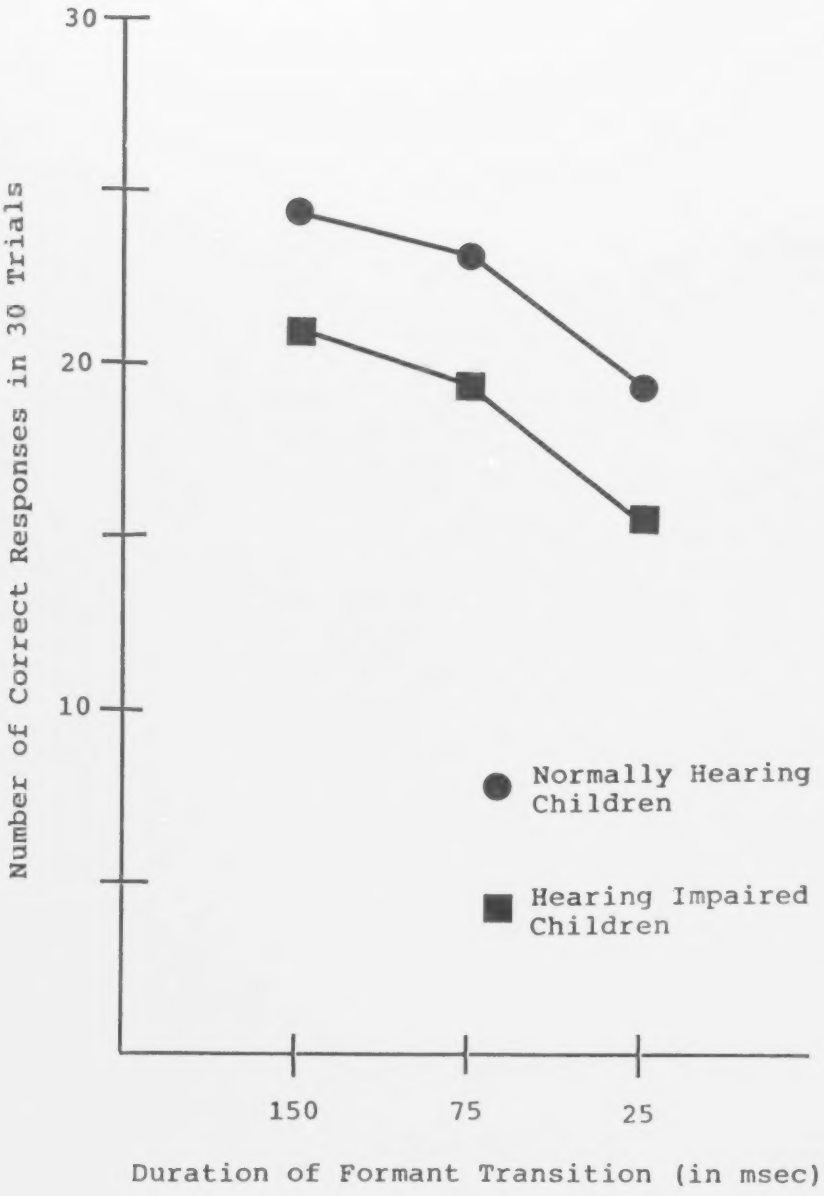

Stimulus-Change Trial.




No-Change Control Trial.

Structure of Experimental Trials.

Slide 6


30
20
10
Number of Correct Responses in 30 Trials
Normally Hearing Children
Hearing Impaired Children
150
75
25
Duration of Formant Transition (in msec)

ANOVA Summary Table

| Source | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| Hearing Status | 240.54545 | 1 | 240.54545 | 18.56 | < .05 |
| Error | 259.21212 | 20 | 12.96061 | | |
| DFT | 286.39394 | 2 | 143.19697 | 24.78 | < .05 |
| HS X DFT | 2.45455 | 2 | 1.22727 | 0.21 | .81 |
| Error | 231.15152 | 40 | 5.77879 | | |

Planned Othogonal Comparisons:

Differences Between Stimmulus Contrasts

| Comparison | Subject Group | t | p |
|---|---|---|---|
| 150 & 75 msec | all | 2.10 | < .05 |
| | normally hearing | 0.82 | N.S. |
| | hearing impaired | 1.28 | N.S. |
| 75 & 25 msec | normally hearing | 1.79 | < .05 |
| | hearing impaired | 1.79 | < .05 |

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